

# Claims

[c1] What is claimed is:

1. A method for patterning an HfO<sub>2</sub>-containing gate dielectric, the method comprising:

providing a wafer having a trench, a STI layer formed in the trench, the HfO<sub>2</sub>-containing gate dielectric covering the wafer and the STI layer, a gate electrode formed on the HfO<sub>2</sub>-containing gate dielectric, and at least a spacer formed beside the gate electrode;

preheating the wafer; and

providing a bromine-rich gas plasma to remove portions of the HfO<sub>2</sub>-containing gate dielectric.

[c2] 2. The method of claim 1 wherein the method comprises utilizing a lamp tray heater to preheat the wafer.

[c3] 3. The method of claim 1 wherein the method comprises utilizing a non-reactive gas plasma to preheat the wafer.

[c4] 4. The method of claim 1 wherein the bromine-rich gas plasma comprises a Br<sub>2</sub> plasma, a HBr plasma, or a mixture of a Br<sub>2</sub> plasma and a HBr plasma.

[c5] 5. The method of claim 1 wherein concentration of the bromine-rich gas plasma is higher than 30%.

- [c6] 6. The method of claim 1 wherein the wafer is preheated to a controlled temperature of higher than 200°C.
- [c7] 7. The method of claim 1 wherein the STI layer comprises SiO<sub>2</sub>.
- [c8] 8. The method of claim 1 wherein the spacer comprises SiO<sub>2</sub>.
- [c9] 9. The method of claim 1 wherein the gate electrode comprises TaN or TiN.
- [c10] 10. The method of claim 1 wherein the wafer further has a sacrifice layer formed on the gate electrode.
- [c11] 11. The method of claim 10 wherein the sacrifice layer comprises SiO<sub>2</sub>.
- [c12] 12. A method for etching an HfO<sub>2</sub>-containing dielectric, the method comprising:  
providing a wafer having the HfO<sub>2</sub>-containing dielectric;  
preheating the wafer; and  
providing a bromine-rich gas plasma to remove portions of the HfO<sub>2</sub>-containing dielectric.
- [c13] 13. The method of claim 12 wherein the method comprises utilizing a lamp tray heater to preheat the wafer.
- [c14] 14. The method of claim 12 wherein the method com-

prises utilizing a non-reactive gas plasma to preheat the wafer.

- [c15] 15. The method of claim 12 wherein the bromine-rich gas plasma comprises a Br<sub>2</sub> plasma, a HBr plasma, or a mixture of a Br<sub>2</sub> plasma and a HBr plasma.
- [c16] 16. The method of claim 12 wherein concentration of the bromine-rich gas plasma is higher than 30%.
- [c17] 17. The method of claim 12 wherein the wafer is pre-heated to a controlled temperature of higher than 200°C.
- [c18] 18. A method for patterning an HfO<sub>2</sub>-containing gate dielectric, the method comprising:  
providing a wafer having a trench, a STI layer formed in the trench, the HfO<sub>2</sub>-containing gate dielectric covering the wafer and the STI layer, a gate electrode formed on the HfO<sub>2</sub>-containing gate dielectric, and at least a spacer formed beside the gate electrode;  
performing a nitrogen ion bombardment to convert the exposed HfO<sub>2</sub>-containing gate dielectric to an Hf<sub>3</sub>N<sub>4</sub> layer; and  
utilizing a phosphoric acid to remove the Hf<sub>3</sub>N<sub>4</sub> layer.
- [c19] 19. The method of claim 18 wherein the STI layer comprises SiO<sub>2</sub>.

- [c20] 20. The method of claim 18 wherein the spacer comprises SiO<sub>2</sub>.
- [c21] 21. The method of claim 18 wherein the gate electrode comprises TaN or TiN.
- [c22] 22. The method of claim 18 wherein the method comprises utilizing a nitrogen gas or a nitrogen-contained gas to perform the nitrogen ion bombardment.
- [c23] 23. The method of claim 18 wherein the phosphoric acid comprises a H<sub>3</sub>PO<sub>4</sub> solution.
- [c24] 24. The method of claim 18 wherein the Hf<sub>3</sub>N<sub>4</sub> layer is removed at temperature between 50°C and 300°C.
- [c25] 25. A method for etching an HfO<sub>2</sub>-containing dielectric, the method comprising:  
providing a wafer having the HfO<sub>2</sub>-containing dielectric;  
performing a nitrogen ion bombardment to convert portions of the HfO<sub>2</sub>-containing dielectric to an Hf<sub>3</sub>N<sub>4</sub> layer; and  
utilizing a phosphoric acid to remove the Hf<sub>3</sub>N<sub>4</sub> layer.
- [c26] 26. The method of claim 25 wherein the method comprises utilizing a nitrogen gas or a nitrogen-contained gas to perform the nitrogen ion bombardment.
- [c27] 27. The method of claim 25 wherein the phosphoric acid

comprises a  $\text{H}_3\text{PO}_4$  solution.

[c28] 28. The method of claim 25 wherein the  $\text{Hf}_3\text{N}_4$  layer is removed at temperature between  $50^\circ\text{C}$  and  $300^\circ\text{C}$ .